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SHARP PC-1500 POCKET COMPUTER SOLUTIONS TO COMPOSITE MATERIALS FORMULAS



WON J. PARK UNIVERSAL ENERGY SYSTEMS, INC. DAYTON, OHIO 45432

and

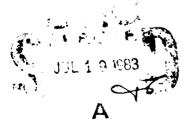
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S.W. TSAI, Project Engineer & Chief

Mechanics and Surface Interactions Branch

Nonmetallic Materials Division

FOR THE COMMANDER

F&D. CHERRY, Chief

Nonmetallic Materials Division

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Composite Materials		
Properties of Unidirectional In-Plane and Flexural Stiffn	and Laminated Compos less and Strength	ite
Mestract (Continue on reverse side if neces This volume contains the des PC-1500 Packet Computer for	cription and instruct	ions of the use of Sharp
PC-1500 Pocket Computer for of symmetric laminated compo practical use. The formulas	Sites. Instant calcu	lations can be made for

practical use. The formulas and equation numbers used in the performed

programming have been derived from a book entitled, Introduction to Composite Materials, co-authored by S. W. Tsai and H. T. Hahn, published by Technomic

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### **FOREWORD**

This report was prepared in the Mechanics and Surface Interactions Branch (AFWAL/MLBM), Nonmetallic Materials Division, Materials Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio. The work was performed under Contract F33615-82-C-5001; SB5448-82-C-0086.

The time period covered by this report was from June to December 1982. Dr. Won J. Park was a senior scientist from Universal Energy Systems, Inc. and Professor of Mathematics and Statistics at Wright State University.

Dr. Thierry N. Massard was a visiting scientist at Materials
Laboratory, Air Force Aeronautical Laboratories, Wright-Patterson AFB,
Dayton, Ohio, and a Chief engineer at the Commissariat L'Energie
Atomique, Montrouge, France.

The equations and table numbers which appear in the flow charts are the same as in Introduction to Composite Materials, co-authored by S.W. Tsai and H.T. Hahn, published by Technomic Publishing Company, Westport, CT, in July 1980.

Those who want to receive the programmed magnetic cassette tape should contact Stephen W. Tsai, AFWAL/MLBM, Wright-Patterson AFB, Dayton, Ohio 45433, Tel: 513-255-3068.

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# SECTION I

### **USER GENERAL INSTRUCTIONS**

- (1) The program language for PC-1500 Pocket Computer is BASIC and the elementary part of BASIC program instructions are given in the SHARP Intruction manual, which comes with PC-1500 Pocket Computer.
- (2) The 8 K RAM should be attached to the computer to increase its capacity. Printer is necessary for Version 1 and 2. If not available, choose Version 3 of the program.
- (3) The programs are called SYM-LAM 1, SYM-LAM 2, and SYM-LAM 3. They are three different displays of the same calculation:
  - SYM-LAM 1 (Version 1) gives vertical printing on the paper,

    SYM-LAM 2 (Version 2) gives horizontal printing with matrix form
    on the paper,
  - SYM-LAM 3 (Version 3) gives results on the display window and does not require the printer.

The programs are started in mode RUN by instruction RUN (press the keys R U N and ENTER). User is guided through the programs by simple questions. The user types the chosen answer and presses the key ENTER.

(4) The programs are recorded on a magnetic cassette with tape counter readings:

SYM-LAM 1 : 0 - 200

SYM-LAM 2 : 250 - 400

SYM-LAM 3 : 450 - 540

Instruction CLOAD "SYM-LAM 1" ("SYM-LAM 2" or "SYM-LAM 3") is used to load the program from the cassette recorder to the computer.

(5) The program considers only symmetric laminates of composite materials.

# SECTION II

### CONTENTS OF PROGRAMS

The program performs specific operations and computations of composite materials:

- (1) Description of the laminates.
  - number of angles
  - number of plies for each angle
  - number of core plies (for flexural stiffness of sandwich plate only)
- (2) In-plane stiffness of symmetric laminates.
  - modulus and compliance
- (3) Engineering constants.
- (4) Normalized in-plane stiffness.
  - modulus and compliance
- (5) In-plane strength.
- (6) Stress failure enevelope.
- (7) Strain failure enevelope.
- (8) Flexural rigidity of symmetric sandwich plates.
  - modulus and compliance
- (9) Flexural strength of symmetric sandwich plates.

# REMARKS:

(a) The materials constants are stored in the program. When

# REMARKS: (cont'd)

"MATERIAL N. =" is asked, input the material number or press M, which gives the menu for materials numbers:

- 1 T300/5208
- 2 B(4)/5505
- 3 AS-3501
- 4 Schotchply/1002
- 5 Kevlar 49/Epoxy

To add other materials (up to 10), user should type (in PRO mode) for a material N. = x: (line 10 \* x)

10 \* x: DATA "Name of Material",  $E_x$ ,  $E_y$ ,  $v_x$ ,  $E_s$ ,  $h_o$ , X, X', Y, Y', S: RETURN

An example of adding a new material (Aluminum-material number 6) is as follows:

Set PRO mode, write 60 DATA "ALUMINUM", 69E3, 69E3, .3, 26.5E3, .125E-3, 400, 400, 400, 230: RETURN and press ENTER.

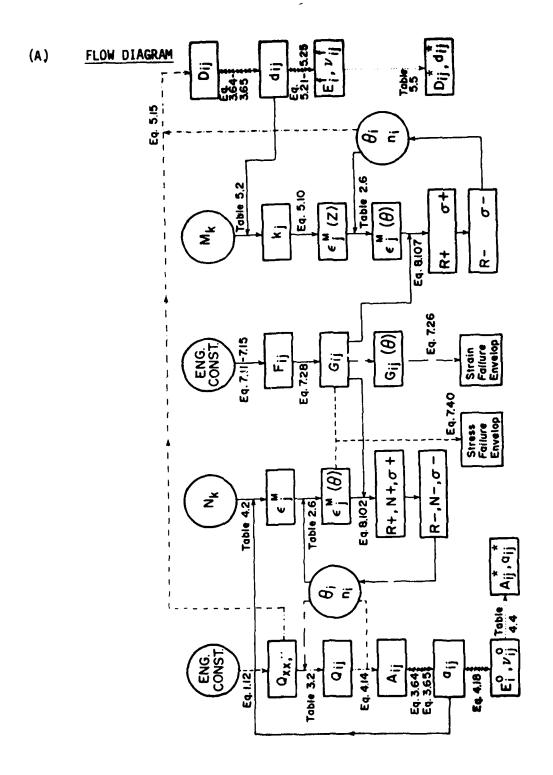
The unit of engineering constants are in MPa and thickness is in meter.

(Do not forget to save the modified program on the cassette tape using instruction CSAVE "SYM-LAM1" ("SYM-LAM2" or "SYM-LAM3"). The menu is set automatically up to date.

- (b) The order of angles to be entered starts from the angle closer to the mid-plane. This is very important in the flexural rigidity and strength computations.
- (c) The value of  $F_{Xy}^*$  was programmed as  $0 = -\frac{1}{2}$  in the program step 1025. For  $F_{Xy}^* \neq -\frac{1}{2}$ , the new value should be entered directly in the program at this step (mode PRO).

# SECTION III

# PROGRAM DESCRIPTION



# (B) <u>KEY OPERATION PROCEDURE</u> (T300/5208, $[0_4/90_4]_s$ and version 1)

DISPLAY & OPERATION	PRINT OUT & REMARKS	DISPLAY & OPERATION	PRINT OUT & REMARKS
RIU N ENTER		ENGINEERING CST	- Y/N? E1-o 95.991GPa
COLOR (0,1,2,3)	Color Numbers 0 - black 2 - green 1 - blue 3 - red	LENIEN	E2-0 95.991GPa E6-0 7.170GPa U210 0.030 U120 0.030
MATERIAL N. = (M for MENU)? M ENTER	Menu for Materials		∪610 Ø.000 ∪160 Ø.000 ∪620 Ø.000 ∪260 Ø.000
MATERIAL N. = (M for MENU)? 1 ENTER	⊺ <b>300</b> ∕5208	NORMALIZED CST Y ENTER	- Y/N? NORMALIZED CONST MODULUS
DEFINE THE LAMIN HOW MANY ANGLES    ENTER   ANGLE =	ATE		A11* 96.078GPa A22* 96.078GPa A12* 2.896GPa A66* 7.170GPa A16* 0.000GPa A26* 0.000GPa
90 ENTER NO. OF PLIES 41	ANGLE 1 = 90 NO.OF PLIES = 4 ANGLE 2 = 0		INU. MAT.(TPa)-1 COMPLIANCE all* 10.417
ANGLE = O ENTER NO. OF PLIES	NO.OF PLIES = 4  N.OF CORE PLIES   Ø		a22* 10.417 a12* -0.314 a66* 139.470 a16* 0.000 a26* 0.000
N. OF CORE PLIES OF CORE PLIES		IN-PLANE STRENGT Y ENTER N1 = (MN/m) ENTER	H - Y/N? N1 = 1.000MN/m N2 - 0.000MN/m N6 - 0.000MN/m
IN-PLANE STIFFNE	IN PLANE STIFFNE MODULUS	II ENTER	AND F. 1 - 98 - 1 - 1 - 1 - 1 - 1 - 1 N - 22 - 888 Samt 323 - 385196
	A22 192.157MN/m A12 5.793MN/m A66 14.340MN/m A16 0.000MN/m	N6 =	ଟ୍ରାଲ 4, 32 N : 4, ମଣ୍ଡ Sam :- 2268, 818M50
	0.000MN/m COMPLIANCE 011 5.208m/kN 022 5.208m/kN	O) ENTER	ANDER 2 - M Re - 1,363 Nr - 12,000 Same: 681,882MPL
	a12 0.157m/kN a66 69.735m/kN a16 0.000m/kN a26 0.000m/kN		RH 2 2,215 NH 2 8,100 Cam - 1107, 185MPa

DISPLAY & OPERATION	PRINT OUT & REMARKS	DISPLAY & OPERATION	PRINT OUT & REMARKS
FAIL. ENV. IN ST	RESS - Y/N?	COLOR NO. IS =	
ENTER ANGLE NO. is=		ANGLE NO. IS =	
ENTER COLOR NO. is= O ENTER		ENTER NEW SCALE - Y/N? N ENTER	
ANGLE NO. is=		FLEXURAL_STIFFNE	S - Y/N?
COLOR NO. is=		Y ENTER	FLEX. STIFFNESS MODULUS
ENTER ANGLE NO. is=(*) 5 ENTER NEW SCALE - Y/N?			D11 106.918N.m D22 21.186N.m D12 1.931N.m D66 4.780N.m D16 0.000N.m
Y ENTER W = ?	(*)Entering an angle number greater than the number of angles		N26 0.000N.m INU.MAT.(kN.m)-1 COMPLIANCE
ENTER	on the laminate ter- minates the graphic operation		d11 9.368 d22 47.228 d12 -0.853 d66 209.205
ANGLE NO. is=			d16 0.000 d26 0.000
COLOR NO. is=		ENGIN. FLEX. CST	- Y/N? E1-f 160.113GPa
ENTER ANGLE NO. is=	1875.0MPa	ENTER	E2-f 31.726GPa E6-f 7.169GPa v21f 0.091
COLOR NO. is=  [2]  ENTER			√12f 0.018 √61f 0.000 √16f 0.000 √62f 0.000
ANGLE NO. is=		NORM ELEV CCT	v261 0.000
NEW SCALE?		NORM. FLEX. CST. Y ENTER	- Y/N? NORMALIZED CONST MODULUS D11* 160.378GPa
ENTER FAIL. ENV. IN ST Y	RAIN - Y/N? STRAIN SPACE		D22* 31.7296Pa D12* 2.896GPa D66* 2.120GPa
ENTER ANGLE NO. IS =	9.022222		
COLOR NO. IS =			COMPLIANCE d11* 6.245
OL ENTER ANGLE NO. IS =			d22* 31.518 d12* -0.569 d66* 139.420
ENTER	<u>1</u>		d16* 0.000 d26* 0.000

DISPLAY OP	& ERATION	PRINT OU	T & REMARKS	DISPLAY & OPERATION	PRINT OUT & REMARKS
	L STRENGTH Y ENTER	- Y/N?	eritgenesser us a surge		ANGLE 2 = 0 R+ = 0.000 Sgm+= 1187.969MPa
M1 =	ENTER 1. ENTER	M2 =	1.000MN 0.000MN 0.000MN		R- = 0.001 <b>Se</b> m-= 1705.573MPa
M2 =	ENTER OI ENTER	R+ =	= 90 0.000 253.541MPa	again to IN-PLA	he program it starts NE STIFFNESS. To end
M6 =	ENTER OI ENTER	1	0.004 213 <b>.872</b> MPa	ION ("break")	gram, press the key
	LENTERJ				

# (C) MEMURY CONTENTS

Memory	DESCRIPTION	VEI	RS 10	ON 3	Memory	DESCIPRTION	VER	S I	0N 3	Memory	DESCRIPTION	VE 1	2	<u>3</u>	
А	E <sub>x</sub>				S	γ'				<b>A</b> (2)	$E_2^0$ $E_2^f$				
В	Ey				T	S				A(3)	$E_6^0$ $E_6^f$				
С	νx				U	×o				A(4)	$v_{21}^{0}  v_{21}^{f}$			_	
D	E <sub>s</sub>				٧	y <sub>o</sub>				A(5)	ν <mark>12 " ν</mark> 12				
F	$m=(1-v_xv_y)^{-1}$				W	scale factor			х	<b>A</b> (6)	v <sub>61</sub> " v <sub>61</sub>			_	
G	k = number of Angles				Х	х				A(7)	ν <mark>0 " γ</mark> f				
Н	*				γ	у				A(8)	ν <sub>62</sub> " ν <sub>62</sub>				
I	*				Z	*				A(9)	ν <sup>0</sup> 26 ν <sup>f</sup> 26				
J	*				AA	**				B(1)	N+	1			
К	N <sub>1</sub> M <sub>1</sub>				ВВ	**				B(2)	N-				
L	N <sub>2</sub> M <sub>2</sub>		T		СС	**			×	B(3)	σ+				
М	N <sub>6</sub> M <sub>6</sub>				II	*	x		x	B(4)	σ-				
N	*				LL	**	×		×	B(10	) H <sub>11</sub>	1		1	
0	F* xy				PP	**	×		×	B(20	H <sub>12</sub>				
Р	Х	1	1		ΤΤ	*				B(21	) H <sub>22</sub>			$\prod$	
Q	X,				XX	*				B(23	H <sub>1</sub>		$\perp$	1	
R	Υ				A(1)	$E_1^0$ $E_1^f$				B( 24	H <sub>2</sub>				

* Nor	DESCRIPTION	VE 1	RS I	ON 3	Memory	DESCRIPT	TION	VEI	RS I	ON 3	Memory	DESCRIPTION	VE 1	RS 10	)N 3
U(1)	F <sub>xx</sub>				U(21)	G <sub>12</sub>	2				V(16)	A* D*66			
U(2)	F <sub>x</sub>				U(22)	G <sub>66</sub>	5				V(17)	* * A <sub>16</sub> D <sub>16</sub>			
U(3)	F <sub>yy</sub>				U(23)	G <sub>1</sub>					V(18)	A* D*			
U(4)	F <sub>y</sub>				U(24)	G <sub>2</sub>					۷(19)	a* d*11			
U(5)	Fss				V(1)	A <sub>11</sub>	D <sub>11</sub>				V(20)	a* d*22			
U(6)	F <sub>xy</sub>				V(2)	A <sub>22</sub>	D <sub>22</sub>				V(21)	a* d* 12			
U(7)	G xx				V(3)	A <sub>12</sub>	D <sub>12</sub>				V(22)	a* d*			
U(8)	G yy				V(4)	A <sub>66</sub>	D <sub>66</sub>				V(23)	a* d* 16			
U(9)	G xy				V(5)	A <sub>16</sub>	D <sub>16</sub>				V(24)	a* d* 26			
U(10)					V(6)	A <sub>26</sub>	D <sub>26</sub>				V(25)	graphic variables			×
U(11)	G <sub>x</sub>				V(7)	a <sub>11</sub>	d <sub>11</sub>				V(31)				×
U(12)	<sup>G</sup> y				V(8)	a <sub>22</sub>	d <sub>22</sub>				X(1)	Q <sub>xx</sub>			
U(13)	Œ				V(9)	a <sub>12</sub>	d <sub>12</sub>				X(2)	Q <sub>yy</sub>			
U(14)	Α'				V(10)	<sup>a</sup> 66	d <sub>66</sub>				X(3)	Q <sub>xy</sub>			
U(15)	В'				V(11)	a <sub>16</sub>	<sup>d</sup> 16				X(4)	0 <sub>ss</sub>			
U(16)	D' R+				V(12)	<sup>a</sup> 26	<sup>d</sup> 26				X(5)	m <sup>4</sup>			
U(17)	E' R-				V(13)	A* 11	D*11				X(6)	m <sup>3</sup> n			
U(19)	G <sub>11</sub>				V(14)	A*22	D*22				X(7)	m <sup>2</sup> n <sup>2</sup>			
U(20)	G <sub>22</sub>				V(15)	A <sub>12</sub>	D*12				X(8)	mn <sup>3</sup>			

	DESCRIPTION	YE	RSI	ON.		DESCRIPTION	VΕ	RSI	ON		DESCRIPTION	VΕ	RSI	ON
	DESCRIPTION	1	2	3		DESCRIPTION	1	2	3			1	2	3
X(9)	n <sup>4</sup>				Y(I)	θi				L\$	" <sup>\\</sup> 12"			
X(10)	h, $\frac{h^2}{6}$ , $\frac{h^3}{12}$				Z(I)	n <sub>i</sub>				M\$	" <sup>\\</sup> 21"			
X(11)					A\$	"11"				N\$	" <sup>\\</sup> 16"			
<b>★</b> X(16)	q <sub>1j</sub>				В\$	"22"				0\$	" <sup>\\</sup> 61 <sup>"</sup>			
X(17)	$\epsilon_1^{\circ}$ $k_1$				C\$	"12"				P\$	" <sup>∨</sup> 26 <sup>"</sup>			
X(18)	ε <sup>0</sup> k <sub>2</sub>				D\$	"66"				Q\$	" <sup>\)</sup> 62 <sup>"</sup>			
X(19)	ε <sup>0</sup> k <sub>6</sub>				E\$	"16"				T\$(1)	11 11			
X(20)	ε <sub>χ</sub>				F\$	"26"				T\$(2)	и 🖈 и			
X(21)	ε <sub>y</sub>				G\$	Y/N				AA\$(1)	"MODULUS"			
X(22)	ε <sub>s</sub>			L	н\$	ANGLE				AA\$(2)	"COMPLIANCE			L
X(23)	m²				1\$	"E1~"				W\$	"MATERIAL"			
X(24)	n²				J\$	"E2~"				C(I,J)	MATRIX ENTRY VARIABLES	x		x
X(25)	mn				K\$	"E6-"				E	h <sub>o</sub>			
X(26)	X(1)													
X(29)	<b>↓</b>													

<sup>\*</sup> Control variable

\*\* - Formate or Printing variable

x - memory is not applicable  $\alpha$  = rotation angle for ellipse

A' - E = Coefficient of elliptic equation rotated

# (D) SAMPLE PROBLEMS

- 1. T300/5208,  $[0_2/90_2/\pm 45_2]_s$  (Version 1)
- 2. T300/5208,  $[0_4/90_4]_s$  (Version 2)
- 3. T300/5208,  $[0/90/\pm 45/CORE_4]_s$  (Version 1)
  - 1. T300/5208,  $[0_2/90_2/\pm45_2]_s$  (Version 1)

T300/5208 ANGLE 1 // 45	NORMALIZED CONST	R- = 1,350 N = 12,000 Sgm== 625,025MFu
NO.OF PLIES = 2  ANGLE 2 = 45  NO.OF PLIES = 2  ANGLE 3 = 90  NO.OF PLIES = 2  ANGLE 4 = 0  NO.OF PLIES = 2	A11* 76.368GPa A22* 76.368GPa A12* 22.607GPa A66* 26.880GPa A16* 0.000GPa A26* 0.000GPa	ANGLE 3 = 588 R+ 0.552 N, 39.888 Ngada 276.1193
N.OF CORE PLIES 0	INU. MAT.(TPa)-1 COMPLIANCE	No. 1292.584704
MODULUS	a11* 14.352 a22* 14.352	4N61 r 4 = [8]
A11 152.736MN/m A22 152.736MN/m A12 45.214MN/m A66 53.760MN/m	012* -4.248 066* 37.201 016* 0.000 026* 0.000	R4 = 1.163 N4 = 14.000 -934 = 581.81171.
A16 0.000MN/m A26 0.000MN/m	N1 = 1.000MN/m	R= 1.130 N= 16.000 Sin= 561.417M=2
COMPLIANCE	N2 = 0.000MN/m N6 = 0.000MN/m	STRESS SHOUL
011 7.176m/kN 022 7.176m/kN 012 -2.124m/kN 066 18.600m/kN 016 0.000m/kN	9NGLE 1 43 R+ = 0.693 N+ = 24.000 Sgm+= 346.995MPa	1875.0MPa
a26 0.000m/kN E1-0 69.675GPa E2-0 69.675GPa	R- 1,350 N- 12,000 Sgm 625,025MPa	
0210 0.296 0120 0.296 0610 0.000 0160 0.000 0620 0.000	ANGLE 2 - 45 R+ 9.593 N+ - 24.000 S9m+ 46.995MPG	
J260 9.000		

# STRAIN SPACE

0.022222

# FLEX. STIFFNESS MODULUS

D11	26.842N.m
D22	44.692N.m
D12	5.216N.m
D66	8.065N.m
D16	2.679N.m
D26	2.629N.m

# INU.MAT.(kN.m)-1 COMPLIANCE

31.1	13.240
d22	22.958
d12	-1.30 <i>7</i>
d56	127.697
d16	-3,963
d26	·2.192

<b>5.</b> 0	, , , , , ,
E1+	113.282GPa
E2-1	65.334GPa
E6- f	11.7 <b>46</b> GPa
√21f	0.098
U125	0.056
J611	0.299
V164	-0.N31
J621	0.313
J261	0.056

# NORMALIZED CONST. MODULUS

D11*	115.2 <b>63</b> GPu
D22*	62.038GPa
D12*	7.824GPa
D66*	12.097GPa
D16#	4.018GPa
D26*	4.018GPa

# INU. MAT. (TPa)-1 COMPLIANCE

d11*	8.827
d22*	15.3 <b>0</b> 5
d12*	- <b>0.</b> 871
d66*	<b>8</b> 5.131
<b>d</b> 16 <b>*</b>	-2.642
<b>#</b> 826	-4.794

$$R- = 0.003$$
  
 $S_{9m-}= 4963.999MPa$ 

$$R-=0.001$$
  
Sgm-= 2954.782MPa

$$R^{-} = 0.000$$
  
 $S_{9m} = 1143.139MPa$ 

2. 1300/5208,  $[0_4/90_4]_s$  (Version 2)

o 95,9916Pa o 95,9916Pa							
E1-0	- P	521	012	.61	016	262	256
•	0.000	9.666	14.340		9.888	9.000	69,735
ų.	5, 793	192.157	999.	n)-1	-0.157	5,208	0.000
IN PLANE STIFF.	192.157	5, 793	200		5, 208	-8,157	9.888
T300/5208 ANGLE 1 = 90	No OF PLIES = 4	NG F 2 F 2	NO OFF DI LFS # 4			ייייייייייייייייייייייייייייייייייייי	

NI = 1.00MN/= ANGLE 2 = 0 STRESS SPACE	E	39 =+m65	8.888 ANGLE 1 = 98 R- = 2.2154	11 02	N+ = 22.8888   S9m-= 1107.7853MPa   (1508 Ann.		) )		3CC
	1 11 N 97	9.699			 	=+465		8.888 IN-	E-805   022 58.
		2.896	96.078					.0.417	•
NORMAL12ED MATR1	Δ*(;j) GPα	96.978	2.836	9.888		a*(: 3) TPa-1	10.417	-0.314	999

168.1136Pa 31.7266Pa 7.1696Pa 8.031 8.008 8.000 0.000 E1-f E2-f E6-f C21f V12f V61f V62f V62f 8.888 8.888 283.285 8.888 8.888 4.788 1.931 21.186 8.888 -8.853 47.278 8.888 FLEX. STIFF.
|D(:j) N.m | 106:918 | 1.931 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 | 2 | 0.000 STRAIN SPACE

ANGLE 2 = 0.888 R+ = 0.888 Sym+= 1187,969MPa	8- 8- 8- 80 1 20- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1-	59m-= 1/65.5/371Fa	
1.8877 8.8877 8.8877	NGLE 1 = 90	K+ = 0.000 S9m+= 1253.541MPa	R- = 0.004 S9m-= 7213.872MPa
E E E	PNGLE	S9m+m	- Ω. S9 % - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
9.000 0.000	7.178	8.888 8.888	139.470
×. 2.896 31.729	0.000	- <b>0.</b> 569 31.518	9.888
MORMALIZED FLEX. D*(:j) GPa 160.378 2.896 3	9.000 d*(;;) TPa-1	<b>6.</b> 245 - <b>0.</b> 569	6.669

# 3. T300/5208, $[0/90/\pm45/\text{CORE}_4]_s$ (Version 1)

T300/52		INU. MAT. (COMPLIANCE		STRES	S SPALF
ANGLE 2 NO.OF ANGLE 3 NO.OF ANGLE 4	PLIES = 1 = 45 PLIES = 1 = 90 PLIES = 1	a22* 14 a12* -4 a66* 32 a16* 0	.352 .352 .248 .201 .000	2	000.0MPa
	RE PLIES 4	N1 = 1	.000MN/m		
IN PLAN	E STIFFNE	N2 = 0	.000MN m		
A11 A22 A12 A66	76.368MN/m 76.368MN/m 22.607MN/m 26.880MN/m -0.000MN/m	Ni = 24	. 346	STRAI	n space
916 926	-0.000MN/m	$R = 0$ $N = 12$ $S_{9m} = 625$		0.	022222
COMPLIA	NCE				
o11 o22 a12 a66 a16 o26	14.352m/kN 14.352m/kN -4.248m/kN 32.201m/kN 0.000m/kN 0.000m/kN		.346 .000 .9956Fu .675 .000		
E1-0 F2-0 E6-0	69.625GPa 69.625GPa 26.880GPa	ANULE 2		FLEX. ST MODULUS	IFFNESS
∪210 ∪120 ∪610 ∪160 ∪620 ∪260	0.296 0.296 0.000 0.000 0.000 0.000	R4	1.276	D11 D22 D12 D66 D16 D26	52.932N.m 43.555N.m 9.491N.m 11.984N.m 1.624N.m 1.624N.m
NORMAL 1 MODULUS	ZFD CONST	Sam 1.4	. 784MPu	INU.MAT.	(kN,m)-1 NCE
011* 022* 012* 066* 016* 026*	76.368GPa 26.368GPa 22.607GPa 26.880GPa -0.000GPa	NF 0 34 NF0F4 1911 R- 0 P N 0 36	А 1.581 1.80Р 1.811МР 1 1.565 1.90Р 5.412МР 1	d11 d22 d12 d66 d16 d26	19.716 23.983 -4.213 84.129 -2.166 -2.762

```
76.079GPa
E1-f
                       M1 =
                               1.000MN
                       M2 = 0.000MN
        62.542GPa
E2-f
        17.829GPa
E'6- f
                       M6 =
                                0.000MN
        0.213
√21 f
√12f
        0.175
                       ANGLE 1 = -45
√61 f
        -0.109
                       R+ = 0.000
√16f
        -0.025
                       Sgm+≈ 617,319MPa
∨62 f
        -0.115
        -0.032
∨26 f
                       R- = 0.000
                       Sgm-= 1258.085MPa
NORMALIZED CONST
MODULUS
                       ANGLE 2 = 45
D11*
        79.398GPa
                       R+ = 0.000
Sgm+= 486.485MPa
        65.333GPa
D22*
        14.237GPa
D12*
        17.976GPa
D66*
                       R- = 0.000
         2.511GPa
D16*
                       S<sub>9</sub>m-= 1115.317MPa
D26*
         2.511GPa
INU. MAT. (TPa)-1
                       ANGLE 3 = 90
COMPLIANCE
                       R+ = 0.000
Sym+= 342.839MPa
        13.144
d11*
        15.989
d22*
                       R- =
                               0.001
        -2.808
d12*
                       Sgm-= 1739.766MPa
        56.086
d66*
d16*
        -1.444
                       ANGLE 4 = 0.000
d26*
        -1.841
                       Sgm+= 606.418MPa
                        R- ≃
                                0.000
                        Sgm-= 684.798MPa
```

# (E) PROGRAM LISTING

# 1. SYM - LAM 1

t:"SYM-LAMI":
INPUT "COLOR ? (0, 1, 2, 3)"; CC:
COLOR CC
2: TEXT 3:DIM X(30), Y(20
), 2(2Ø), U(25),
A(31), B(31), V( 24), A\$(2)
4: DATA "11", 22" . 12", "66", "16
, 12", "66", 116 ', "26"
SPRESTORE 4:FOR 1-1TO 6.READ @
<b>★</b> (!):NEX!!
6:DATA "E1-", "E2
6:DATA "E1-", "E2 -", "E6-", "\\21" \"\\12", "\\61", "\\ \\16", "\\62", "\\2
016", '⊍b2", '⊍2 6'
7. RESTORE 6. FOR 1=910 17. READ
DIG ( ) ) NEXT
8: INFUT "MATERIA L N.=(M FOR ME
NU)"; G\$: 1F G\$=
"M"GOTO 195 9:[≔UAL 6\$*10:
GOSUB I: RESTORE 1.READ W\$,A,B,C,D,E,P
W\$, A, B, C, D, E, P
.0,R,S,T: LPRINT W\$:6010
200
200 14. DATA 11300/520 81. 181.3, 10.3E 3. 28. 1.1733. 125E 3. 1500, 15
3 28 143 1552 - 2. 1588. 15
14.12 (

DR, 40, 246, 68.

5", 204L3, 18.5E

3, .23, 5.59£3, . 125£ 3, 1262, 25

00, 61, 202, 67.

. 138£3, 8.96£3,

30, 7. 10E3, . 12

5E-3, 1447, 1442

. 51, 7, 206, 93;

30. PATA "ASZ3501"

20. DATA 18(4)/550

RETURN

RETURN

RETURN

```
49: DATA "SCOTCHPL
   Y/1002", 38.6E3
   , B. 273, . 26, 4. 1
   4E3, .125E-3, 10
   62, 610, 31, 118,
   72: RETURN
50: DATA "KEULAR 4
   9/EPOXY", 76E3,
   5.5E3, .34, 2.30
   E3, .125E-3, 140
   0, 235, 12, 53, 34
   : RETURN
60: DATA '
    RETURN
20: DATA "
    RETURN
80:DATA " ".
    RETURN
 90: DATA " ":
    RETURN
100:DATA
    RETURN
190:USING "&&&&###
    ###.###";
    RETURN
191:USING "&&&&&&&
    8&&&&&&&":
    RETURN
195:FOR 1=1TO 10:
    GOSUR 1*10:
    RESTORE 1*10:
    READ W$
197: PAUSE 1;
       "; W$. NEXT 1:
    8 GTGG
200:LF (1):A$(1)="
    MODULUS": 4$(2)
     - "COMPLIANCE",
    99-190:88-191
210: PAUSE "DEFINE
    THE LAMINATE"
220: F=1/(1-C*C*B/A
230: X(1) = F *A, X(2) =
     F*B, Y(3)=F*C*B
     ,×(4)≈D
260: INPUT "HOW MAN
     Y ANGLES=13G
 270:FOR 1=110 G
```

```
300: LPRINT H$; Y(1)
310: INPUT "NO. OF P
    L1ES=";7(1)
315: LPRINT " NO. OF
     FLIES = ";7(I
316: NEXT 1
317: INPUT "N. OF CO
    RE PLIES=(FLEX
    1";7(0)
318: LPRINT USING "
    8888888888888
    &###"; "N.OF CO
    RE PLIES"; Z(0)
320: PAUSE "ANSWER
    YAN FOR LISTIN
    G"
323: INPUT "IN-PLAN
    E STIFFNESS -
    YZN?"; G$
324:X$#"IN PLANE S
     TIFFNESS"
327:GOSUB 670:
     GUSUB 680
 329:FOR ]=1TO 6
 330: 00SUB 200
 335: X(10)=X(10)+2*
     E*2(1)
 340: d(1)~2*2(1)*E
 350: BOSUB 1100
 360: NEXT 1
 965: 7965. TEP. XX 1
      J$="MN/m". IF
     0$="Y"G05UR 38
     B
 3.75: 0.0TO 540
 380:Li (I).LOLUR I
 390: FOSUB BB:
     LPRINT X$, A$(T
     T76+10;LF (1)
 400: DSUR AA: FOR I
       170 6
 405: LPRINT CHR$ 25
     @$(1); /(1+T*)*
     XX;U$
 410:NEXT LIRETURN
 490.18 (1):COLOR 1
 497: 1$="CPa"
 500:FOR 1-110 9
 505: XX=1E-3: IF 1>3
      THEN LET XX=1,
     U$=""
```

STR# (1)+" ="

280: INPUT "ANGLE="

290: H#="ANGLE "+

;٧(\*)

510:GOSUB 190: LPRINT @\$(1+8)	720:X(9)=(SIN Y(I)	1 <b>030:</b> U(6)= <b>0*f</b> (U(1 )*U(3))
+CHR\$ Z; A(I)*X	740:X(11)=X(1)*X(5	1040:U(2)=U(1)*X(
X;U\$	)+X(2)*X(9)+2*	1>^2+2*U(6)*
515; NEXI 1	X(7)*(X(3)+2*X	X(1)*X(3)+U(
518: RETURN	(4))	3)*X(3)^2
540: GOSUB 800	750:X(12)=X(1)*X(9 )+X(2)*X(5)+2*	1050:U(8)-U(1)*X( 3)^2+2*U(6)*
560:X\$="";Z=97:TT= 6:XX=1E3:U\$="m	X(Z)*(X(3)+2*X	X(3)*X(2)+U(
/kN": IF G\$="Y"	(4))	3)*X(2)^2
GOSUB 380	760:X(13)=X(7)*(X(	1060:U(9)=U(1)*X(
580:GOSUB 1200	1)+X(2)-4*X(4)	1)*X(3)+U(6)
585: Z=111	)+X(3)*(X(5)+X	*(X(1)*X(2)+
590: INPUT "ENGINEE	(9))	X(3)^2)+U(3)
RING CST - Y/N	770:X(14)=X(7)*(X( 1)+X(2)-2*X(3)	*X(3)*X(2)
? ";G\$	)+X(4)*(X(5)-2	1070:U(10)=U(5)*X (4)^2,U(11)=
592:IF G\$="Y"GOSUB 490	*X(Z)+X(9))	U(2)*X(1)+U(
600: INPUT "NORMALI	78Ø:X(15)=X(1)*X(6	4)*X(3),U(12
ZED CST - Y/N?	)~X(2)*X(8)+(X	)=U(2)*X(3)+
¨;G\$	(8)-X(6))*(X(3	U(4)*X(2)
602:X\$="NORMALIZED	)+2*X(4))	1080:RETURN
CONST."	790:X(16)=X(1)*X(8	1100:0(1)=0(1)+0(
605: Z=65: TT=12: XX=	)-X(2)*X(6)+(X	1)*X(11), U(2
1E-3:U\$="GPa":	(6)-X(8))*(X(3 )+2*X(4))	)=U(2)+U(1)* X(12),U(3)=U
TF G\$="Y"GOSUB	795: RETURN	(3)+U(1)*X(1
630 610:X\$="INU. MAT.(	800: DT=U(1)*U(2)*U	3)
TPa)-1"	(4)+2*U(3)*U(6	1110:0(4)=0(4)+0(
615:7=97:TT=18:XX=	) <b>*</b> U(5)-U(2) <b>*</b> U(	1)*X(14),U(5
1E6:∪\$="":⊺F G	5)^2-U(4)*U(3)	)=U(5)+U(])*
\$="Y"GOSUB 630	^2-U(1)*U(6)^2	x(15), U(6)=U
620:GOTO 1300	820:U(7)=(U(2)*U(4	(6)+U(1)*X(1
630:LF (1):GOSUB 1	)-U(6)^2)/DT 825:U(8)=(U(1)*U(4	6)
91:LPRINT X\$,9 \$((TT-9)/6+1):	)-V(5)^2)/DT	1130:RETURN 1200:A(1)=1/X(10)
LF (1)	830:0(9)=(0(5)*0(6	/U(2), A(2)=1
640:FOR 1=1TO 6	)-U(3)*U(4))/D	/X(10)/U(8),
645: GOSUB AA:	т	A(3)=1/X(10)
LPRINT CHR\$ Z+	840:U(10)=(U(1)*U(	/U(1Ø)
@\$(1)+"*";U(1+	2)-U(3)^2)/DT	1210:A(4)=-U(9)/U
TT)*XX;U\$	850:U(11)=(U(3)*U(	(7), A(5)≈-U(
650:NEXT 1:RETURN 670:FOR J≈10TO 16	6)-U(2)*U(5))/ DT	9)/U(8 <b>),</b> A(6) =U(11)/U(7)
672:X(J)=0:NEXT J	860:U(12)=(U(3)*U(	1220:4(7)=U(11)/U
625: RETURN	5)-0(1)*0(6))/	(10), A(8)=U(
680:FOR 1=1TO 6	TO	12)/U(8), A(9
684:U(I)=0	980: RETURN	)=U(12)/U(10
688: NEXT I	1000:U(1)=1/P/Q,U	)
690: RETURN	(2)=1/P-1/Q	1230:FOR J=1TO 6
700:X(5)=(CDS Y(1)	1010:U(3)=1/R/S,U (4)=1/R-1/S,	1235; U(J+12)=U(J)
)^4, X(6)=(COS Y(1))^3*SIN Y(	U(5)=1/T/T	/X(10) 1237:U(J+18)=U(J+
1)	1020:U(3)=1/R/S,U	6)*X(10)
710:X(7)=(COS Y(I)	(4)=1/R-1/S	1240: NEXT J
*SIN Y(1))^2, X	U(5)=1/T/T	1270 RETURN
(8)=COS Y(1)*(	1025:0=-1/2	
SIN Y(1))^3		

	1560.U/30\-U/17\#	
1300: TEXT : COLOR	1560:X(20)=X(17)*	1680: LPRINT "Sam-
2	X(23)+X(18)*	=";B(4);"MPa
1320: INPUT 'IN PL	X(24)+X(19)*	, j D ( 12 ) 1 1 U
ANE STRENGTH	X(25)	1685 RETURN
YZN?";C\$	1570:X(21)=X(17)*	1200:GRAPH .COLUR
1330:LF (1):1F 6\$	X(24)+X(18)*	
="N"GOTO 260	X(23)-X(19)*	2
0	X(25)	1201.GLCURSOR (12
1340: 2-28: U\$="MN/	1580:X(22)=2*X(25	0,-120):
	)*(X(18)-X(1	SORGN
m":GOSUB 139	7))+X(19)*(X	1702:LINE (0, -100
Ø	(23)-X(24))	)-(0, !00), 0,
1350:COTO 1420	1585:Y(I)=-Y(I)	1
1390:LF (1):FOR I	1590: RETURN	1203.LINE (-100,0
=11T0 1 <b>3</b>	1600:U(13)=U(7)*X	)-(100, 0), 0,
1395:X\$=CHR\$ Z+	(20)^2+2*U(9	1
MID\$ (@\$(1~2	)*X(20)*X(21	1705: INPUT "ANGLE
$0,2,1>+^{n}=^{n};$	)+U(8)*X(21)	NO.1S=";!
PRINT X\$+"("	^2+U(10)*X(2	1210: IF IDGTHEN 2
+U\$+")":	2)^2	520
INPUT 0(1)	1605;U(14)=U(11)*	1211:AREAD Y(1)
1400:005UR AA.	X(20)+U(12)*	1212: AREAD 2(1)
LPRINT X\$;@(	X(21)	1215.INPUT "COLOR
1)14	1610:U(15)=U(14)/	
1410:NEXT 1.	U(13)/2	NO.15=";7
	1615:U(16)=-U(15)	12124 <b>X(26)</b> = <b>X</b> (1.5, <b>X</b>
RETURN	+1(U(15)^2+1	(27)-X(2),X(
1420:Y(12)=U(2)*K		28)=X(3), X(2
+U(9)*L+U(11	/U(13))	9)=X(4)
)*M	1620:U(17)=U(15)+	1,720:COSUB 1000
1430: M(18): U(9)*K	1(U(15)^2+1/	1230:X(1)=U(2);Y(
+U(8)*L+U(12	U(13))	2)=U(8), Y(3)
) <b>*</b> M	1625:B(1)=INT(X)	~U(9), X(4)~U
1440:X(19)-U(11)*	10)/E/U(16)/	(10)
K+U(12)*L+U(	2+1)*2, B(2)=	1240:COSUB 620
10)*M	INT (X(10)/E	1220.COSUB 200
1450:FOR 1/110 C	/U(17)/2+1)*	1280:XC1\=XC26\;X\.
1460:4\$="ANGLE"+	2	(2)-X(22), X(
GIR\$ (1)+1	1630:B(3)=U(16)/X	3)=X(28), Y(4
	(10),B(4)=U(	1=8(29)
1420:LF (1)	17)/X(1Ø)	1818:0(19)-8(11)
1480: USING "&&&&&	1635: RETURN	
8&&&####"	1650:1F G\$="N"	U(20) = X(12),
1492: 1 G\$: "Y"	THEN 1685	UC2124XC133,
LPRINT H\$;Y(	1653: USING "&&&&&	J(22)=X(14)
•	#####, ###"	1820. Y(23)=(00) Y
1)	1655:LPRINT "R+	$(1)) \land 2, (24)$
1500.10SUB 1550	=";U(16)	=(SIN Y(1))0
1501:605UB 1000	1657:IF U\$="MN"	2
1102: LUSUB 1600	THEN 1665	1830: J(23)J(11)*
1510:00SUB 1650	1660:LPRINT "N+	X(23)+U(12)*
1520: NEXT I	=";B(1)	X(24), U(24)
1530:COTO 2600	1665:LPRINT "Sgm+	J(11)*X(24)+
1550:Y(1)= Y(1)	=";B(3);"MPa	U(12)*X(23)
1555; X(23) = (COS Y	, 2 , 2 , 3 , 4 , 4	1835.15 N-2THEN 2
$(11)(2, \times (24))$	1670: LPRINT "R-	300
-(SIN Y(1))A	=";U(12)	1840; B(19)=U(19)*
2, 8(25) = 605	1672: IF U\$="MN"	V(2)^2+U(21)
Y(I)*SIN Y(I	THEN 1680	*U(2)*U(9)+U
)	16/5:LPRINT "N-	(20)*U(3)*U
		(20) 本い(さ い)/ 1
	=";8(2)	

U(22)*U(11)^	23 <b>60:</b> U(16)::U(23)*	2575; TF N≈1THEN
2	COS U(13)+U(	LET K=60/XX/
1850; Ř(20)=U(19)*	24)*SIN U(13	W:GOTO 2585
	)	2580: K=60/W
U(9)^2+U(21)		
*U(9)*U(8)+U	2320: U(12)U(23)	2585: GLCURSOR (-6
(20)*U(8)^/+	. *SIN U(13)+U	0,90):SORGN
U(22)*U(12)0	(24)*COS U(1	2586: IF N=2THEN 2
2	3)	588
1860:B(21)=U(19)*	2380:U(18)=1+U(16	2587: USING "#####
U(Z)*U(9)+U(	<b>)</b> ^2/U(14)/4+	#.#&&&";GOTO
21)*U(7)*U(8	U(12)^2/U(15	2590
)+U(20)*U(9)	)/4	2588: USING "##.##
	2390:X=1(U(18)/U(	4###
*U(8)		
1820:B(21)#B(21)+	14)), Y=1(U(1	2590; LPRINT K; U\$.
U(22)*U(11)*	8)/U(15))	TEXT LF 10
J(12)	24 <b>00:</b> U=-U(16)/U(1	2591. TEXT RETURN
1880.B(23)=U(23)*	4)/2, U= ·U(12	2600: XX-X(10): N=1
U(2)+U(24)*U	)/U(15)/2	∪\$-"MPa":
(9)	2410:H≔U*COS U(13	INPUT "FAIL.
1890.9(24)/U(231*	)-U*SIN U(13	ENU. IN STRES
V(9)+U(24)*V	),M≃U*SIN U(	S - Y/N?";G\$
	13)+V*COS UC	1 IF G\$#"N"
(8)	13)	
1900.JC19>-BC19>,		THEN 2640
U(20)-B(20),	2420: U=H, J=M	2601: USING "&&&&&
J(21)-B(21),	2430: X=X*W, Y=Y*W,	8888888888
U(23)~B(23),	U=U*W, U=U*W	8888888"
J(24)-B(24)	2480:A(0)=X*COS U	2605: TEXT LE (2)
2300.0 U(19) U(20	(13)+U,B(0)=	2610: W-30
)	X*SIN U(13)+	2615:LPRINT " S
2310:1F O MAND UC	U	TRESS SPACE
21) >0THEN 23	2490:FOR J 1TO 31	2620:GOSUR 1700
30	2500:A(J)=X*COS (	2630: INPUT "NEW S
	12*J), B(J)=Y	CALE Y/N?"
2315: D 0 0AND UC	*SIN (12*J)	; G\$: 1F C\$="N
21 YOTHEN 23	2510:M=A(J)*COS U	
3.1		"GOTO 2640
2320.7(13) (ATN C	(13) B(J)*	2635: INPUT "W= ?"
2*U(21)/(U(1	SIN J(13), H=	:W:G0'0 2615
97-5(20)))77	ACJO#SIN UCI	2640.N 2.U\$~"";
2.00TC 2340	3)+P(J)*COS	INPUT 'FAIL.
2334.1(13):45:	U(13)	ENU.'N STRAI
60TO 234Ø	2520.4(J) M+U, B(J	N - YZNPY; U\$
2335: 101352-45	) <i>=</i> H+U	. 15 G\$±"N"
2340.UC14)=UC13)*	2540:LINE (ACJ 1)	THEN 2200
(COS U(13))^	, B(J-15)/ (AC	2641: USING "&&&&&
2+2*U(21)*	D, B(J (), 0, 2	8888888888
	2550: NEXT J	8&&&&&&&&
COS UC13)*		2645; TEXT LF (2)
SIN U(13)+U(	2560: GOTO 1705	
20)*(51N UC	2570: LINE (-4, 60	2650.W-2200
3))^2	)-(4, -60), 0,	2655.LPRINT " S
23504.0(15) U(19)*	1	TRAIN SPACE
(SIN JCI31)	2572:LINE (-4,60)	2660.GOSUB 1200
2~2*!!(21)*	-(4,60),0,!	2620: INPUT "NEW S
:IN U(13)*	2523:LINE (60, -4)	LALE ?YZN",G
COS U(13)+U(	-(60,4),0,1	\$.IF G\$="N"
20)*(COS_U(1	2574; LINE (+60; -4	GOTO 2200
3))^2	)-(-60, 4), 0,	2680: INPUT "W= ?"
***	1	:W:GOTO 2655
	•	

```
2200: GOSUP BRILE
                     3165: INPUT " FLE
                           XURAL STRENG
     (1)
2210. INPUT " LEXU
                           TH - YZN? ";
     RAL STIFFNES
                           G$
                      3170: IF G$-"N"
     S - Y/N?", 3$
2220:X$="FLFX. ST
                           GOTO 3330
                      3180: Z=77: U$="MN"
     TEFNESS"
2240.LF (1):GOSUB
                           :GOSUB 1390
     620: CUSUB 68
                      3200:X(17)=U(7)*K
                           +U(9)*L+U(11
2765;X(10)::Z(0)*E
                           ) *M
2220.FOR 15110 G
                      3210:X(18)=U(9)*K
2280: GOSUB 200
                           +U(8)*L+U(12
2785:X(10)=X(10)+
                           ) *M
     E*2(1)
                      3220:X(19)=U(11)*
2290.U(1)=2/3*(X(
                           K+U(12)*L+U(
     10) 43-(X(10)
                           10)*M
                      3230: A(0)-2(0)*E
      Z(I)*E)^3)
2800:00SUP 1100
                      3232.W=X(10)
2820: NEXT 3
                      3235: Y(10)=1/6*
2850: 4-68: TT-0:XX
                           EXP (2/3*LN
     =186.U$="N.m
                           (X(10)*12))
     ". IF 0$ "Y"
                      3240: FOR 1:1TO G
     G0SUB 388
                      3250.A(I)=A(I-1)+
2910:00SUP 800
                           Z(1)*E
2920. X$ - "INU. MAT.
                      3255:LF (1)
     (kN.m)-1"
                      3260:H$= ANGLE "+
                           STR$ (1)+" =
2930.2-100.TT-6.X
     X-1E 3.U$=""
     √ኒ⊨ ር$#"∀"
                      3268. TE L$5"N"
     G0SUR 380
                           GOTO 3225
2940:X(10)≈2*X(1ñ
                      3270:USING "&&&&&
     103/3
                           888888###"
:950:GOSUB 1200
                           LPRINT H$;YC
2960: 7-102
                           D
2965. INPUT FINGIN
                      3225,00SUB 1555
      FLIX.EST Y
                      3222, Y(1)=-Y(1)
     /NT": 1$
                      3280. DSUB 1000
2920. " 6$ "Y"
                      3285; X(20)::X(20)*
     GOSUB 490
                           A(1), X(21)=X
RANG. INPUT "NORM.
                           (21)*A(1), X(
     FLEX.:ST
                           221-8(22) #AC
     ZN?"; 0$
                           1.5
3005.Y$ "NURMALIZ
                      3290:00SUB 1000
     FD LONST"
                      3300:GUSUB 1650
3010, 7.68; 71.12, 3
                      3310. NEXT 1
     Y 16 3:U$ 'G
                      3320: X(10): W
     Pa". H G$ "Y
                      3330: FOTO 323
     "COSUR 630
3740:X$ "INU. MAT
      (Ira)-1"
3050.0 100: 11-18:
     XX-1:6:U$-1
      JE C$ - "V"
     GCSUB 630
3160: OLOR 2
```

- 1: "SYM-LAM2":
   INPUT "COLOR ?
   (0,1,2,3)"; CC
   : COLOR CC
- 2:GRAPH ROTATE 1.KK=1: GLCURSOR (200, 0):11=1:SORGN
- 3: DIM X(30), Y(20), L(3, 3), U(24), T\$(2), Z(20), U(25), A(31), B(31)
- 7.DATA 1,3,5,3,2 .6,5,6,4.FOR 1 =110 3:FOR J=1 TO 3:READ CCI, 1):NEXT J:NEXT 1.GOSUB 140
- 8: INPUT "MATERIA L N. = (M FDR M ENU)"; G\$. !F G\$ = "M"GOTO 195
- 9: THUAL G\$\*10: GOSUB 1: RESTORE 1.READ W\$, A, B, C, D, E, P . Q, R, S, T: LPRINT W\$: GOTO 200
- 10.DATA 1300/520 8", 18163, 10.3E 3, 28, 7.17E3, 2 125E 3, 1500, 15 00, 40, 246, 68; RETURN
- 20. DATA "B(4)/550 5", 204E3, 18.5E 3, .23, 5.59E3, 1 25E-3, 1260, 250 0, 61, 202, 62. RETURN
- 30. DATA "AS/3501 . 138E3, 8. 96E3, 30, 7. 10E3, .12 5E 3, 1442, 1442 .51. 2, 206, 93-RETURN
- 40.DATA "SCOTCHPL Y 1002 .38.6E3 .8.22E3 .26,4. '4E3, .125E-3,' 062.610,31,118 .72.RETURN

- 50: DATA "KEULAR 4 9/EPOXY", 76E3, 5.5E3, .34, 2.30 E3, .125E-3, 140 0, 235, 12, 53, 34 : RETURN
- 60: DATA "": RETURN 70: DATA "": RETURN 80: DATA "": RETURN 90: DATA "": RETURN 100: DATA "": RETURN
- 140: DATA "E1-", "E2 -", "E6-", "U21" , "U12", "U61", " U16", "U62", "U2
- 150:RESTORE 140: FOR 1-9TO 17: READ Q\$(1): NEXT 1:RETURN

6"

- 190: USING ' &&&&&&& &&&&&&&&\*; RETURN
- 191:USING "####### ,###":RETURN
- 195:FOR 1-1TO 10: GOSUB !\*10: RESTORE !\*10: READ W\$
- 197. PAUSE I; -- ; ws: NEXT I. GOTO 8
- 200: T\$(1) %"". T\$(2) ="\*". 9A-191. PP =4E3: LL=5E3
- 210: PAUSE 'DEFINE THE LAMINATE"
- 220:F=1/(1-C\*C\*B/A
- 230:X(1) =F\*A, X(2) = F\*B, X(3) =F\*C\*B , X(4)=D
- 260: INPUT "HOW MAN Y ANGLES-"; G
- 270: J=0:FOR I=1TO G: J=J+1
- 280: [NPUT "ANGLE="
- 290:4\$="ANGLF "+ STR\$ (1)+" ""
- 300:GOSUB LL. LPRINT !!\$; Y(I)
- 310: INPUT "NO. DE P

- 313:COSUB LL:
  LPRINT " No OF
  PLIES = ";7(I
  ):[F J=4GOSUB
  PP:]=0
- 315:NEXT I 316:INPUT "N.OF CO RE PLIES=(FLEX )":2(0)
- 317: GOSUB LL: GOSUB LL: LPRINT USING "&&&&&& &&&&&& N.OF CORE PLIE S": Z(0)
- 318.KK=1.1:COSUB P
- 320: PAUSE "ANSWER Y/N FOR"
- 322: INPUT "IN-PLAN E STIFFNESS YZN?"; G\$: X\$="I N PLANE STIFF. "; N=1
- 328:GOSUB 620. GOSUB 680
- 329:FOR 1=110 6 330.COSUB 200
- 335: \(\10) \(\times \(\10) + 2 \)
  E\(\times \(\times \(\10) \)
- 340:U(1)=2\*Z(1)\*E
- 350: GOSUB 1100
- 360: NEXT 1
- 365.GOSUB 800: GOSUB 1200
- 370:IF O\$ -"Y"GOSUB 620:COSUB 385
- 375.GOTO 590
- 385:7=65.W=19:TT=0 .U\$="MN/m",XX= 1.COSUB 630
- 390: 7292. W220: 7126 U\$2"(kN/m)-1" XX=1E3: GOSUB 630
- 332. GOSUR PP: RETURN
- 497:KK=1.U\$="GPa"
- 500: FOR 1-110 9
- 505: XX=1L=3.1F 123 THEN LET XX=1, U\$=''
- 510:GOSUR LL:

LPRINT USING "	710:X(7)=(COS Y(I)	1020:U(3)=1/R/S,U
88888";0\$(1+8)	<b>*</b> S1N Y(1))^2, X	(4)=1/R-1/S,
+CHR\$ Z;USING	(8)≃UDS Y(I)*(	U(5)=1/T/T
"####.###";ACI	S1N Y(1))^3	1025:0=5;U(6)-0
)*XX;USING '&&	720:X(9)=(SIN Y(I)	<b>*1(U(1)*</b> U(3)
8.";U\$	) 04	)
515: NEXT 1: GOSUB P	740:X(11)=X(1)*X(5	1040:U(Z)=U(1)*X(
P:RETURN	)+X(2)*X(9)+2*	1)^2+2*U(6)*
590: INPUT "ENGINEE	X(2)*(X(3)+2*X	X(1)*X(3)+U(
RING CST- Y/N	(4))	3) <b>*</b> X(3)^2
? ';G\$	750:X(12)=X(1)*X(9	1050:U(8)=U(1)*X(
592: Z=111: IF G\$="Y	)+X(2)*X(5)+2*	3)^2+2*U(6)*
"GOSUB 497	X(2)*(X(3)+2*X	X(3)*X(2)+U(
600: INPUT "NORMALI	(4))	3)*X(2)^2
ZED CST - Y/N	760:X(13)=X(7)*(X(	1060:U(9)=U(1)*X(
? "; G\$: X\$="NOR	1)+X(2)-4*X(4)	1)*X(3)+U(6)
MALIZED MATRIX	)+X(3)*(X(5)+X	*(X(1)*X(2)+
":N=2	(9))	X(3)^2)+U(3)
605:IF G\$="Y"GOSUB	770:X(14)=X(7)*(X(	*X(3)*X(2)
620: COSUB 625	1)+X(2)-2*X(3)	1070:U(10)=U(5)*X
610:GOTO 1300	)+X(4)*(X(5)-2)	(4) <sup>2</sup> , U(11)=
620:kk-2:GOSUB 190	*X(2)+X(9))	U(2)*X(1)+U(
:LPRINT X\$:II=	780:X(15)=X(1)*X(6	4)*X(3),U(12
1: GOSUB LL:	)-X(2)*X(8)+(X	)=U(2)*X(3)+
RETURN	(8)-X(6))*(X(3	U(4)*X(2).
625: GOSUB LL: Z=65:	)+2*X(4))	RETURN
W=19:U\$="GPa":	79 <b>0:</b> X(16)=X(1)*X(8	1100:0(1)=0(1)+0(
TT=12:XX=1E-3:	)-X(2)*X(6)+(X	1)*X(11),U(2
GOSUB 630	(6)-X(8))*(X(3	)=U(2)+U(1)*
627: GOSUB LL: 2-92:	)+2*X(4))	X(12), U(3)-U
₩=20:U\$="TPa-1	795: RETURN	(3)+U(1)*X(1
":TT::18.XX=1E6	800:DT=U(1)*U(2)*U	3)
:GOSUB 630:	(4)+2*U(3)*U(6	1110:0(4)=0(4)+0(
GOSUB PP	1*U(5)-U(2)*U(	1)*X(14), U(5
RETURN	5)^2-U(4)*U(3)	)=U(5)+U(1)*
630:GOSUP 190:	^2-U(1)*U(6)^2	X(15), U(6)=U
LPRINT CHR\$ F'+	820: J(2)=(U(2)*U(4	(6)+U(1)*X(1
T\$(N)+1(13)	)-U(6)^2)/DT	6) RETURN
"+U\$;@\$(W):	825: 7(8)=(0(1)*0(4	1200:A(1)-1/X(10)
GOSUB AA: GOSUB	)-U(5)^2)/DT	/U(2), A(2)
EL	830: J(9)=(U(5)*U(6	/X(10)/U(8),
634:FOR 1:110 3:	)-U(3)*U(4))/D	9(3)=1/X(10)
FOR J=110 3	T (3)#0(4///5	/U(10)
636; LPRINT UCC(1, )	840:U(10)=(U(1)*U(	1210:0(4)=-0(5)/0
)+TT)*XX;NEXT	2)-U(3)^2)/DT	(2), A(5)=-U(
T: GOSUB LL:	850:U(11)=(U(3)*U(	9)/((8), 4(6)
NEXT I:RETURN	6)-U(2)*U(5))/	~U(11)/U(2)
620: FOR J-10TO 16:	DT	1220:A(7):U(11)/U
X(J)=0:NEXT J:	860:0(12)=(0(3)*0(	(10), A(8)=U(
RETURN	5)-0(1)*0(6))/	12)/0(8),4(9
690:FOR 1-170 5:UC	DT:RETURN	)=U(12)/U(18
D=0:NEXT 1.	1000:U(1)=1/P/Q,U	>
RETURN	(2)=1/P-1/Q	1230:FOR J≔1™O 6
700:X(5)-(COS Y(1)	1010:U(3)-1/R/S,U	1235;J(J+12)=J(J)
)^4, X(6)/ (COS	(4)=1/R-1/S	/X(10)
Y(1))^3*51N Y(	U(5)-1/T/T	1 <b>240:∪(J+18</b> )⊴∪(J+
1)	0.0711	6)*X(10).
1.7		

_	1570: X(21)=X(17)*	1672: IF U\$≈"MN"
NEXT 1:	X(24)+X(18)*	THEN 1680
RETURN	X(23)-X(19)*	1675:GDSUB LL:
TRUM: INPUT 'IN-PL	X(25)	LPRINT "N-
ANE STRENGTH	1580: x(22)=2*X(25	=";B(2)
XX <b>N</b> 3 + 2 <b>\$</b>	)*(X(18)~X(1	1680:GOSUB LL:
1300. H 0\$ 1N	7))+X(19)*(X	LPRINT "Sam-
CD TB 2688	(23)-X(24))	=";B(4);"MPa
1310: 78.0\$="MN/	1585:Y(1)=-Y(1):	":RETURN
ns _	RETURN	1700: IF N=1THEN
7358.7080B 7390:	1600:U(13)≈U(7)¥X	LET K=60/XX/
GDTD 1420	(20)^2+2*U(9	W:GOTO 1704
1390: DOSUB LL.FOR	)*X(20)*X(21	1702:K=60/W*100
I 1110 13	1+U(8)*X(21)	1704: PAUSE USING
1395:PRINT CHR\$ 1	^2+U(10)*X(2	88## ##### "
+MIN\$ (@\$(I	2)^2	8888888888
2), 2, 1)+"	1605: U(14)=U(11)*	"; "SCALE UNI
("+U\$+")";	X(20)+U(12)*	T IS";K;U\$
INPUT @(1)	X(21)	1706: INPUT "NEW 5
148P: LPRINT USING	1610:U(15)=U(14)/	CALE ?YZN";G
&&&&&':LHR\$	U(13)/2	\$
2+M1D\$ (@\$1)	1615:U(16)=-U(15)	1708: IF G\$="N"
-2), 2, 1)+1 -	+J(U(15)^2+1	G0T0 1210
#### 2MIRU;	∠U(13))	1709: INPUT "W = ?
. ##88888## : @	1620: U(17)=U(15)+	";W:GOTO 17
(1); U\$. GOSUB	1(U(15)^2+1/	90
LL: NEXT I:	U(13))	1710:GLCURSOR (-7
KETURN	1625: B(1)=1NT (X(	0, -140):
1420: X(12):::U(2)*K	10)/E/U(16)/ 2+1)*2,B(2)=	SORGN
*U(9)*L+U(11	INT (X(10)/E	1715:LINE (0, -120
***	/U(17)/2+1)*	)-(0, 120), 0,
1438, X(18) U(3) *K	2	1 1720:LINE (-100,0
FU(8)*L+U(12	1630:8(3)=U(16)/X	)-(50,0),0,1
1#M - 1440.5(11)#	(10), B(4)=U(	1725: INPUT "ANGLE
X+U(12)*L+U(	17)/X(10);	NO. IS="; 1
18)*M	RETURN	1230: IF 1>GTHEN 2
1450.KK=1.AU.10R	1650: USING "&&&&&	520
1 1TD 6	8.8.8.####"	1235: AREAD Y(I)
158a. busua 1558:	1652: GOSUB LL:	1240: AREAD Z(1)
COSUR 1000.	LPRINT "ANGL	1250. INPUT "COLOR
GOSUR 1600.	E "+STR\$ (1)	NO. 15="; Z
COSUB 1650:	+" =";Y(1)	1760:X(26)=X(1),X
GOSUB PP:	1652/1151NG "RRRRR	(27)≈X(2),X(
NEXT 1	****	28)=X(3), X(2
1530.00TD 2600	1655: GOSUB LL:	9)=X(4)
(350:YCD= Y4D	LPRINT "R+	1770:GOSUB 1000
1555: Y(23) (005 Y	=";U(16)	1780:X(1)=U(7),X(
(1))(2, 3(24)	1657: IF U\$="MN"	2)=U(8),X(3)
(SIN YCD)	THEN 1665	=U(9), X(4)=U
2, 8 (2%) ~ 30%	1660: GOSUB LL:	(10)
*(1)*()IN Y(1	LPRINT "N+	1790:GOSUB 670:
Y	=";8(1)	GOSUB 200
1560.X(20).X(12)*	1665:GOSUB LL: LPRINT "Som+	1800: X(1)=X(26), X
X(23)+X(18+*	=";B(3);"MPa	(2)=X(27),X(
X(24)+X(19)*	= ,p(3), (" \u00c4	3)=X(28), X(4 )=X(29)
¥(25)	1670:GOSUB LL:	
	LPRINT "R-	
	=";U(17)	
	• • •	

	2.0010 2348	
1810:U(19)=X(11),	2:GDTO 2340 2330:U(13)=45:	U(13) 2520:A(J)≃M+U,B(J
U(20)-X(12),	GOTO 2340	)=H+U
u(21)=X(13),	2335: U(13)=-45	2540:LINE (B(J-1)
u(22)=X(14)	2340:U(14)=U(19)*	,-A(J-1))-(B
1820.X(23)-(COS Y	(CDS U(13))^	$(J), -A(J)), \emptyset$
(1))^2, X(24)	2+2*U(21)*	, Z: NEXT J:
=(SIN Y(1))^	CDS U(13)*	GOTO 1725
2 1830:U(23)=U(11)*	SIN U(13)+U(	2570:LINE (-4,-60
X(23)+U(12)*	20)*(SIN U(1	)-(4,-60),0,
X(24), U(24)=	3))^2	1
U(11)*X(24)+	2350:U(15)=U(19)*	2572:LINE (-4,60)
U(12)*X(23)	(SIN U(13))^	-(4, 60), 0, 1
1835: IF N=2THEN 2	2-2*U(21)*	2523:LINE (60, -4)
300	SIN U(13)*	-(60, 4), 0, 1
1840:B(19)=U(19)*	CDS U(13)+U(	2574:LINE (-60, -4
U(2)∧2+U( <b>2</b> 1)	20)*(COS U(1	)-(-60, 4), 0,
*0(2)*0(9)+0	3))^2 2360:U(16)=U(23)*	1 2585:GLCURSOR (~6
(20)*U(9)^2+	COS A(13)+A(	0,90):SORGN
U(22)*U(11)^	24)*SIN U(13	2590:LPRINT K;U\$;
2	)	RETURN
1850:B(20)/U(19)* U(9)^2+U(21)	2370:U(17)=-U(23)	2600:XX=X(10):N=i
*U(9)*U(8)+U	*SIN U(13)+U	.U\$="MPa":
(20)*U(8)^2+	(24)*COS U(1	INPUT "FAIL.
0(22)*0(12)^	3)	ENU.IN STRES
2	2380:U(18)=1+U(16	5-Y/N?";G\$:
1860:B(21)=U(19)*	)^2/U(14)/4+	IF G <b>\$</b> ="N"
U(2)*U(9)+U(	U(17)^2/U(15	THEN 2640
21)*U(2)*U(8	)/4	2610: COSUB 190:
)+U(20)*U(9)	2390: X=1ABS (U(18	GOSUB LL:W:
*U(8)	)/U(14)), Y=1	6
1820:B(21)≈B(21)+	ABS (U(18)/U	2615:LPRINT ' S TRESS SPACE'
U(22)*U(11)*	(15)) 2400: U=-U(16)/U(1	2620: GOSUB 1700:
U(12) 1880:B(23)≃U(23)*	4)/2, U=-U(12	GLCURSOR (13
U(2)+U(24)*U	1/0(15)/2	0, 230): SORGN
(9)	2410: H=U*COS U(13	:KK=2:GOSUB
189 <b>0:</b> B(24)≈U(23) <b>*</b>	1-U*SIN U(13	PP
U(3)+U(24)*U	), M≕U¥SIN U(	2640:N=2:U\$="%";
(8)	13)+U*CDS U(	INPUT "FAIL.
1900:U(19)=B(19),	13)	ENU.IN STRA!
U(20)=B(20),	2420: U=H, U=M	NY/N?";G\$:
U(21) = B(21),	2430: X=X*W, Y=Y*W,	IF G\$##N"
u(23)=B(23),	U=U*W, U∷U*W	THEN 2700
U(24)=B(24)	2480:A(0)=X*COS U	2650:GOSUB 190:ฝ=
2300:0=U(19)-U(20	(13)+U,B(0)= X*SIN U(13)+	2700
)	7*51N 0(13)	2655; LPRINT 5
23:0:1F 0=0AND UC	2490:FOR J=1TO 31	TRAIN SPACE
21)>0THEN 23 30	2500:4(J)=X*CDS (	2660:GOSUB 1200. GLCURSOR (1°
30 2315: [F 0:0AND U(	12*J), B(J) Y	0, 230): SDRGN
21) (0THEN 23	*SIN (12*J)	KK=2: GOSUB
35	2510:M=A(J)*COS U	t)b
2320:U(13)=(ATN (	(13)-B(J)*	2700:GOSUB 190:
2*U(21)/(U(1	SIN U(13), H=	INPUT "FLEXU
9)U(20))))/	4(J)*SIN_U(1	RAL STIFFNES
	3)+B(J)*COS	

SY/N?";G\$:	3030:KK≈2:GOSU8 P
X\$= FLEX. ST	3120:KK≈1.05:
THE NAT	INPUT " FLE
2745: COSUB 670	
2750: GOSUB 680	XURAL STRENG
2/65; X(10)=Z(0)*F	THY/N? ";
2/70:FOR 1:110 L	<b>()\$</b>
2780: GOSUB 700	3130: IF G\$="N"
2285; X(10)=X(10)+	GOTO 3330 3120:Z=22:U\$="MN"
E*Z(1)	: GOSUB 1390
2290:U(1) -2/3*(X(	3200:X(17)=U(7)*K
(0)^3-(X(10)	
Z(1)*E)^3)	+U(9)*L+U(11
2800: GOSUB 1100	)*M 3210:X(18)≈U(9)*K
2820: NEXT I	+U(8)*L+U(12
.2830:005UB 800 .2840:1F G\$="Y"	)*M
COSUB 620:	3220:X(19)=U(11)*
GOSUB 2880	K+U(12)*L+U(
2868: GBTO 2940	10)*M
2880: Z:68.W:19:TT	3230:A(0)=Z(0)*E
2889.2 -00.W 13.1 . :N.m":	3232: W=X(10)
XX-1E6: GOSUB	3235:X(10)=1/6*
630	EXP (2/3*LN
2890:7-100:W-20:1	(X(10)*12))
T-A: U\$="(kN.	3240: FOR 1-1TO G
m)-1 XX 1E	3250:A(1)=A(1-1)+
3.00SUB 630	7(1)*E
2900.KK-2.GOSUB P	3275: COSUB 1555
p	3277:Y(1)=~Y(1)
2940:X(10)=2*X(10	3280:GOSUB 1000
16373	3285:X(20)=X(20)*
2950:00508 1200	9(1), X(21)=X
2960:30102.INPUT	(21)*A(1),X(
"ENGIN.FLEX.	22)≃X(22) <b>*</b> A(
CSI Y/N?",G	1)
\$	3300: COSUB 1500:
2970: IF G\$-"N"	GOSUB 1650:
GO TO 3000	COSUB PP: NEXT I
29/5: GOSUB 49/	3330:00TD 322
RUDD: INPUT MORM.	4000: GLCURSOR (0,
FLEX.EST Y/	-230*KK):
N?"; G\$. N#2; X	SORGN : LINE
\$#"NORMALIZE	(0, 10)-(-200
D FLEX.	. 10), 0:
3010: IF G\$="N"	GLCURSOR (Ø,
GOTO 3120	<b>Ø</b> )
3020:COSUB 620 3022:Z≈68:W=19:U\$	4010:11=0:RETURN
="6Pa" - T=12	5000:CLCURSOR (-2
:XX::11-3:	0*11,0):11=1
GOSUB 630	T+I:RETURN
3025:7:100:W:20:U	
\$="!Pa-1".TT	
=18: XX=1£6:	
GOSUB 63A	
<del></del>	

1: "SYM-LAM3" 3: DIM X(30), Y(20) ), Z(20), U(25), U(24), A\$(2), A( 10), B(31) 4: DATA "11 22" . 12", "66". "16 . 26" 5: RESTORE 4: FOR 1=1TO 6. READ 4 \$(1): NEXT 1 6: DATA "E1-", "E2 -", "E6-", "U21- ", U12-", "U61- ", U16-", U62- ", U26-" 7: RESTORE 6: FOR 1=9TO 17. READ 0\$(1): NEXT 1 8: INPUT "MATERIA L N. = (N FOR ME NU)"; G\$: IF G\$= "M"GOTO 195 9: I=UAL G\$*10: GOSUB I: RESTORE I: READ W\$, A, B, C, D, E, P . G, R, S, T: PRINT W\$: GOTO 200 10: DATA "T300/520 8", 181E3, 10.3E 3, 28, 7.17E3, . 125E-3, 1500, 15 00, 40, 246, 68: RETURN 20: DATA "B(4)/550 5", 204E3, 18.5E 3, 23, 5.59E3, . 125E-3, 1260, 25 00, 61, 202, 67: RETURN 30: DATA "AS/3501" . 138E3, 8.96E3, . 30, 7.10E3, .12 5E-3, 1447, 1447 , 51.7, 206, 93:	50: DATA "KEULAR 4 9/EPOXY", 76E3, 5.5E3, .34, 2.30 E3, .125E-3, 140 0, 235, 12, 53, 34 :RETURN 60: DATA "" 70: DATA "" 90: DATA "" 100: DATA "" 190: USING "&&&&&## ####.##": RETURN 191: USING "&&&&&& &&&&&& &&&&&& &&&&&& &&&&&& &&&&&	318: PRINT USING "&
30:DATA "AS/3501" .138E3, 8.96E3, .30,7.10E3,.12 5E-3,1447,1447	290:H\$="ANGLE "+ STR\$ (1)+" =" 300:PRINT H\$;Y(1) 310:!NPUT "NO.OF P	518:RETURN 540:GOSUB 800 560:X\$="".Z=9Z:TT=

592:1F C\$="Y"GOSUB	780:X(15)=X(1)*X(6	U(2)*X(1)+U(
490	J-X(2)*X(8)+(X	4) <b>*</b> X( <b>3</b> ),U(12
600; N-2: INPUT "NOR	(8)-X(6))*(X(3	)=U(2) <b>*X(</b> 3)+
MALIZED CST -	)+2*X(4))	U(4)*X(2)
YZN? ';G\$	790:X(16)=X(1)*X(8	1080: RETURN
605;2-65;⊌=1;↑T=12	)-X(2)*X(6)+(X	!100:V(1)=V(1)+U(
:XX#1E-3.U\$#"G	(6)-X(8))*(X(3	1)*X(11),U(2
Pa":TF G\$≈"Y"	)+2 <b>*</b> X(4))	)=V(2)+U(I)*
GOSUB 630	795: RETURN	X(12),U(3)#U
615.2=92:W=2:TT=18	800:DT=U(1)*U(2)*U	(3)+U(1) <b>*</b> X(1
: XX=1E6:U\$="TP	(4)+2*U(3)*U(6	3)
a=1".lF G\$="Y"	) <b>*</b> U(5)-U(2 <b>)*</b> U <b>(</b>	1110:U(4)=U(4)+U(
GOSUB 630	5)^2-U(4)*U(3)	1)*X(14),U(5
620:GOTO 1300	^2~U(1)*U(6)^2	)=V(5)+U(I)*
630.GOSUB 191:	820:U(Z)=(U(Z)*U(4	X(15),U(6)=U
PRINT A\$(W)	)-U(6)^2)/DT	(6)+U(1)*X(1
640:FOR 1=110 6	825:U(8)=(U(1)*U(4	6)
645:GOSUB AA:PRINT	)-U(5)^2)/DT	1130: RETURN
CHR\$ Z+Q\$(])+"	830:U(9)=(U(5)*U(6	1200:A(1)=1/X(10)
*";U(I+TI)*XX;	)-U(3)*U(4))/D	√U(Z),A(Z)≔1
<b>∪\$</b>	т	/X(10)/U(8),
650:NEXT 1.RETURN	840:U(10)=(U(1)*U(	4(3)=1/X(10)
620:FOR J=10TO 16	2)-U(3)^2)/DT	/U(10)
622:X(J)=0:NEXT J	850:U(11)=(U(3)*U(	1 <b>210:</b> 4(4)=~U(9)/U
625: RETURN	6)-U(2)*U(5))/	(7), A(5)=-U(
680:FOR 1=110 6	DΤ	9)/U(8), 4(6)
684:U(1)=0	860:U(12)=(U(3)*U(	□U(11)/U(2)
688:NFXT 1	5)-U(1)*U(6))/	1220:4(2):20(11)/0
690.RETURN	DT	(10), 4(8)#JC
700:X(5)=(COS Y(I)	980:RETURN	12)/U(8),A(9
)^4,Y(6)~(COS	1000:U(1)=1/P/Q,U	)=U(12)/U(1A
Y(I))^3*SIN Y(	(2)=1/P-1/Q	)
1)	1010:U(3)=1/R/S,U	1230:FOR J-110 6
210:Y(2)=(COS Y(I)	(4) = 1/R-1/S,	1235:U(J+12)=U(J)
*SIN YCIDDA2, Y	U(5)≈1/T/T	ZX(10)
(8)≥COS Y(1) <b>*</b> (	1020:U(3)-1/R/S,U	1232:U(J+18)=U(J+
SIN Y(I))/3	(4)=1/R-1/S,	6)*X(10)
720:X(9)=(SIN Y(I)	J(5)#I/T/T	1240: NEXT J
)^4	1025:0=-1/2	1270: RETURN
740;X(11)=X(1)*X(5	1030;U(6)=0*J(U(1	1300: INPUT "IN-PL
)+X(2)*X(9)+2*	)*U(3))	ANE STRENGTH
X(2)*(X(3)+2*X	1040:U(2)=U(1)*X(	- Y/N?"; G\$
(4.)	1>^2+2*U(6)*	1338: IF G\$45N"
250.XCI?24XCI?*X <u>C</u> 9	X(1)*X(3)+U(	GOTO 2700
\4\\(2\)\X\(5\)+2\	3)*X(3)^2	1340:7-28:U\$="MNZ
X(Z)*(X(3)+2*X	1050:U(8)=U(1)*X(	m":GOSUB 139
(4))	3)^2+2*U(6)*	9
260.X(13)~X(/)*(X(	X(3)*X(2)+U(	1350: COTO 1420
12+X(2) 4*X(4)	3)*X(2)^2	1390:FOR 1≈11TO 1
)+X(3)*(X(5)+X	1060:U(9)=U(1)*X(	3
(9))	1)*X(3)+U(6)	1395: X\$=CHR\$ Z+
22 <b>0:</b> X(14)=X(2)*(X(	*(X(1)*X(2)+	MID\$ (@\$(1-2
12+X(2)-2*X(3)	X(3)^2)+U(3)	), 2, 1)+" =";
)+Y(4)*(X(5) 2	*X(3)*X(2)	PRINT USING
*X(2)+X(9))	1020:U(10)=U(5)*X	***************************************
	(4)∧2, ∪(11) <i>=</i>	&";\4+"('+U\$

FUD' INPUT @	1605:U(14)=U(11)*	2790:U(I)=2/3*(X(
(1)	X(20)+U(12)*	10)^3-(X(10)
1400:GOSUR AA:	X(21)	-Z(1)*E)^3)
PRIN! X\$,@CI	1610:U(15)=U(14)/	2800: GOSUB 1100
);∪\$	U(13)/2	2820: NEXT I
1410: NEXT	1615:U(16)=~U(15)	2850: Z=68: TT=0: XX
RETURN	+1(U(15)^2+1	=1E6:U\$="N.m ":IF G\$="Y"
1420:X(12)=U(2)*K	<b>/U(13))</b>	GOSUB 380
+U(9)*L+V(II	1620:U(17)=U(15)+	2910:GOSUB 800
) *M	1(U(15)^2+1/	2930: Z=100: TT=6: X
1430: X(18): V(9)*K	U(13))	X=1E-3:U\$=""
+U(8)*L+U(12	1625:B(1)=INT (X(	: IF G\$="Y"
\*M	10)/E/U(16)/	GOSUB 380
1440: X(19): V(11)*	2+1)*2, B(2)=	2934: USING "&&&&&
K+U(12)*L+U(	INT (X(10)/E	888888888
10) *M	/U(17)/2+1)*	8 "
1450:FOR 1 170 G	2	2935: PRINT "
1460: H\$> 'ANGLE "+	1630:B(3)=U(16)/X	in (kN.m)-
STR\$ (1)+0	(10),B(4)≈U( 17)/X(10)	1"
**************************************	1635: RETURN	2940:X(10)=2*X(10
1480: JSINC 188888	1650: IF G\$="N"	103/3
8&&&####* 1490:16 G\$-7Y"	THEN 1685	2950:GOSUB 1200
PRINT H\$:Y()	1653: USING "&&&&&	2960: Z=102
)	4########	2965: INPUT "ENGIN
1500: COSUB 1550	1655: PRINT "R+ =	FLEX.CST
1501.GOSUR 1900	";U(16)	Y/N?";G\$
15 <b>02:</b> GOSUB 1600	1657: IF U\$="MN"	2970: IF G\$#"Y"
1510: GOSUR 1650	THEN 1665	GOSUB 490
1520+NeXI I	1660: PRINT "N+ =	3000: INPUT "NORM.
153 <b>0:</b> 0.010 2744	";B(1)	FLEX.CST - Y
1550: Y(1) - Y(1)	1665: PRINT "Sem+=	✓N?"; G\$
1555: X(23): (CDS Y	";B(3);"MPa"	3005: X\$="NORMAL12
(11)^2, X(24)	1670:PRINT "R- =	ED CONST"
- (SIN YCIDA	";U(12)	3010: Z≈68: W=1: TT=
2, XC250 = COS	1672: IF U\$="MN"	12: XX=1E-3:U
YCID*SIN YCI	THEN 1680	\$="GPa". IF G
`	1675: PRINT "N- =	\$≈"Y"GOSUB 6
1560: Y(20)   X(12)*	(;B(2)	30 3050.7≃100:W=2:TT
Y(23)+Y(18)*	1680: PRINT "S9m-=	=18: XX=1E6: U
X(24)+X(19)*	";B(4);"MPa"	\$="TPa-1": [F
X(25)	1685: RETURN	G\$="Y"GOSUB
1520: \(21)=\(12)*	2550: NEXT J	630
X(24)+X(18)*	2680: INPUT "W≈ ?"	3160: INPUT " FLE
X(23) X(19)*	:W: GOTO 2655	XURAL STRENG
X(25)	2700:GOSUB BB 2710:INPUT "FLEX.	TH - Y/N? ';
1580-X(22) -2*X(23	STIFFNESS -	G\$
)*(X(18) X(1	Y/N?'; G\$	3170: IF G\$="N"
7))+X(19)*(X	2720: X\$="FLEX. ST	GOTO 3330
(23)- X(24)) 1585-Y(1)Y(1)	IFFNESS"	3180: 2=72: U\$="MN"
1590:RETURN	2740: GOSUB 670:	:GOSUB 1390
1600.UC21*X	COSUB 680	3200:X(12)=U(2)*K
(20)^2+2*UC3	2765: X(10)=Z(0)*E	+U(9)*L+U(11
) <b>*X</b> (2) <b>0</b> ) <b>*X</b> (2)	2770: FOR 1=1TO G	) <b>*M</b>
1+8(2) *8(21)	2280: GOSUB 700	3210:X(18)=U(9)*K
N2+U(1/1)*X.2	2285: X(10)=X(10)+	+U(8)*L+U(12
2)^2	E*Z(1)	) <b>*M</b>
*** ? <b>*</b>		

3220: USING 188888 3220:X(19)=U(11)\* 8888888### K+U(12) #L+U( PRINT H\$; YCL 10)\*M 3230:4(0) -/(d)\*E 3225 CASUR 1000 3225 VOLDO YOU 3232:W-X(10) 3235:X(10) 175\* 3288.005UB 1888 EXP (2/3\*LN 329574(20)=XC/d)\* (X(10)\*12)) A(I), X(21 - Y 3240.FOR 1:110 G (21) \*A(1), Y( 3250:4(1)=4(1-1)+ 22) :X(22)\*A( 2(1)\*E 3260: H\$= ' ANGLE "+ 1) STR\$ (1)+" 329N: GOSUB 1600 3300; CUSUB 1650 3268: IF G\$2"N" 3314. NEXT 1 3328. KCIRY W GOTO 3275 439441 NA

# SECTION IV CONCLUSIONS

The description and instruction of the use of Sharp PC-1500

Pocket Computer for the key calculations of the stiffness and strength of symmetric laminated composites are presented in this paper. With the computer packages that were programmed, instant calculations can be made for practical use.

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